

Exercise Solutions for Math 20

Radicals and Complex Numbers

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1 Simplify the following. Rationalize the denominators.

1.1 $\frac{24c^{-\frac{1}{2}}d^{\frac{2}{3}}}{18c^{-\frac{1}{7}}d^{-\frac{3}{5}}}$

$\Rightarrow \frac{4c^{-\frac{1}{2}}d^{\frac{2}{3}}}{3c^{-\frac{1}{7}}d^{-\frac{3}{5}}}$ $\Rightarrow \frac{4d^{\frac{2}{3}}c^{\frac{1}{7}}d^{\frac{3}{5}}}{3c^{\frac{1}{2}}}$ $\Rightarrow \frac{4d^{\frac{2}{3}}d^{\frac{3}{5}}}{3}c^{\frac{1}{7}-\frac{1}{2}}$ $\Rightarrow \frac{4d^{\frac{2}{3}}d^{\frac{3}{5}}}{3}c^{\frac{2}{14}-\frac{7}{14}}$ $\Rightarrow \frac{4d^{\frac{2}{3}}d^{\frac{3}{5}}}{3}c^{-\frac{5}{14}}$ $\Rightarrow \frac{4}{3}c^{-\frac{5}{14}}d^{\frac{2}{3}+\frac{3}{5}}$ $\Rightarrow \frac{4}{3}c^{-\frac{5}{14}}d^{\frac{10}{15}+\frac{9}{15}}$ $\Rightarrow \frac{4}{3}c^{-\frac{5}{14}}d^{\frac{19}{15}}$ $\Rightarrow \frac{4d^{\frac{19}{15}}}{3c^{\frac{5}{14}}}$ $\Rightarrow \frac{4}{3} \frac{\sqrt[15]{d^{19}}}{\sqrt[14]{c^5}}$ $\Rightarrow \frac{4}{3} \frac{\sqrt[15]{d^{19}}}{\sqrt[14]{c^5}} \cdot \frac{\sqrt[14]{c^9}}{\sqrt[14]{c^9}}$	<p>Simplify the fraction to lowest terms.</p> $a^{-\frac{b}{c}} = \frac{1}{a^{\frac{b}{c}}}$ $\frac{a^m}{a^n} = a^{m-n}$ <p>LCM = 14</p> $a^m a^n = a^{m+n}.$ <p>LCM = 15</p> $a^{-\frac{b}{c}} = \frac{1}{a^{\frac{b}{c}}}$ <p>Rationalize.</p>
$\Rightarrow \frac{4}{3c} \frac{\sqrt[14]{c^9} \sqrt[15]{d^{19}}}{\sqrt[14]{c^5}}$	<p>Final answer. ■</p>

1.2 $(u^{\frac{1}{3}} + (uv)^{\frac{1}{6}} + v^{\frac{1}{3}})(u^{\frac{1}{6}} - v^{\frac{1}{6}})$

$\Rightarrow (u^{\frac{1}{3}} + u^{\frac{1}{6}}v^{\frac{1}{6}} + v^{\frac{1}{3}})(u^{\frac{1}{6}} - v^{\frac{1}{6}})$	<p>Distribute exponent.</p>
$\Rightarrow u^{\frac{1}{2}} - v^{\frac{1}{2}}$	<p>Use difference of two cubes.</p>
$\Rightarrow \sqrt{u} - \sqrt{v}$	<p>Final answer. ■</p>

1.3 $\sqrt[3]{-8^4}$

$\Rightarrow -\sqrt[3]{8^4}$ $\Rightarrow -\sqrt[3]{(2^3)^4}$ $\Rightarrow -\sqrt[3]{(2^4)^3}$ $\Rightarrow -2^4$	$\sqrt[m]{-a} = -\sqrt[m]{a} \text{ for odd } m.$ $(a^m)^n = (a^n)^m$
$\Rightarrow -16$	<p>Final answer. ■</p>

1.4 $\sqrt[4]{9x^8}$

$\Rightarrow \sqrt[4]{9}\sqrt[4]{x^8}$	$\sqrt[n]{ab} = \sqrt[n]{a}\sqrt[n]{b}$
$\Rightarrow \sqrt[4]{3^2}\sqrt[4]{x^8}$	
$\Rightarrow x^2\sqrt{3}$	Final answer. ■

1.5 $\sqrt{\sqrt[3]{9a^4b^4}}$

$\Rightarrow \sqrt[6]{9a^4b^4}$	$\sqrt[n]{\sqrt[n]{a}} = \sqrt[n+m]{a}$
$\Rightarrow \sqrt[6]{3^2a^4b^4}$	
$\Rightarrow \sqrt[3]{3a^2b^2}$	Final answer. ■

1.6 $\frac{2\sqrt{5}}{\sqrt{8}} + \frac{9}{\sqrt[3]{16}}$

$\Rightarrow \frac{2\sqrt{5}}{\sqrt{8}} \cdot \frac{\sqrt{2}}{\sqrt{2}} + \frac{9}{\sqrt[3]{16}} \cdot \frac{\sqrt[3]{4}}{\sqrt[3]{4}}$	Rationalize.
$\Rightarrow \frac{2\sqrt{5}\sqrt{2}}{\sqrt{16}} + \frac{9\sqrt[3]{4}}{\sqrt[3]{64}}$	
$\Rightarrow \frac{2\sqrt{5}\sqrt{2}}{4} + \frac{9\sqrt[3]{4}}{4}$	
$\Rightarrow \frac{2\sqrt{5}\sqrt{2}+9\sqrt[3]{4}}{4}$	
$\Rightarrow \frac{2\sqrt{10}+9\sqrt[3]{4}}{4}$	Final answer. ■

1.7 $\frac{x^2-2x+1}{\sqrt{x+1}}$

$\Rightarrow \frac{x^2-2x+1}{\sqrt{x+1}} \cdot \frac{\sqrt{x-1}}{\sqrt{x-1}}$	Rationalize using difference of two squares.
$\Rightarrow \frac{(x^2-2x+1)(\sqrt{x-1})}{x-1}$	
$\Rightarrow \frac{(x-1)^2(\sqrt{x-1})}{x-1}$	Factor by grouping.
$\Rightarrow (x-1)(\sqrt{x-1})$	Final answer. ■

1.8 $\frac{1}{\sqrt[3]{4}-\sqrt[3]{-27}}$

$\Rightarrow \frac{1}{\sqrt[3]{4}+\sqrt[3]{27}}$	$\sqrt[n]{-a} = -\sqrt[n]{a}$ for odd n .
$\Rightarrow \frac{1}{\sqrt[3]{4}+\sqrt[3]{27}} \cdot \frac{\sqrt[3]{4^2}-\sqrt[3]{4}\sqrt[3]{27}+\sqrt[3]{27^2}}{\sqrt[3]{4^2}-\sqrt[3]{4}\sqrt[3]{27}+\sqrt[3]{27^2}}$	Rationalize using difference of two cubes.
$\Rightarrow \frac{\sqrt[3]{4^2}-\sqrt[3]{4}\sqrt[3]{27}+\sqrt[3]{27^2}}{4+27}$	
$\Rightarrow \frac{\sqrt[3]{4^2}-3\sqrt[3]{4}+\sqrt[3]{27^2}}{4+27}$	

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$\Rightarrow \frac{\sqrt[3]{4^2}-3\sqrt[3]{4}+\sqrt[3]{27^2}}{31}$	
$\Rightarrow \frac{\sqrt[3]{16}-3\sqrt[3]{4}+\sqrt[3]{27^2}}{31}$	
$\Rightarrow \frac{\sqrt[3]{16}-3\sqrt[3]{4}+\sqrt[3]{(3^3)^2}}{31}$	
$\Rightarrow \frac{\sqrt[3]{16}-3\sqrt[3]{4}+\sqrt[3]{(3^2)^3}}{31}$	$(a^m)^n = (a^n)^m$
$\Rightarrow \frac{\sqrt[3]{16}-3\sqrt[3]{4}+3^2}{31}$	
$\Rightarrow \frac{\sqrt[3]{16}-3\sqrt[3]{4}+9}{31}$	
$\Rightarrow \frac{\sqrt[3]{8}\sqrt[3]{2}-3\sqrt[3]{4}+9}{31}$	$\sqrt[m]{ab} = \sqrt[m]{a}\sqrt[m]{b}$
$\Rightarrow \frac{2\sqrt[3]{2}-3\sqrt[3]{4}+9}{31}$	Final answer.
	■

2 Perform the following operations and simplify.

2.1 $3i(i^2 - i^3 + 5i^5 - i^{-2})$

$\Rightarrow 3i(-1 - i^3 + 5i^5 - i^{-2})$	Simplify.
$\Rightarrow 3i(-1 + i + 5i^5 - i^{-2})$	$i^3 = -i$
$\Rightarrow 3i(-1 + i + 5i - i^{-2})$	$i^5 = i$
$\Rightarrow 3i(-1 + i + 5i + 1)$	$i^{-2} = -1$
$\Rightarrow 3i(6i)$	
$\Rightarrow 18i^2$	
$\Rightarrow -18$	Final answer. ■

2.2 $(3 - 5i)(7 + 4i)$

$\Rightarrow 21 + 12i - 35i - 20i^2$	Expand.
$\Rightarrow 21 + 12i - 35i + 20$	
$\Rightarrow 41 - 23i$	Final answer. ■

2.3 $\frac{3i-2}{3i+2}$

$\Rightarrow \frac{-2+3i}{2+3i}$	Rewrite in standard form.
$\Rightarrow \frac{-2+3i}{2+3i} \cdot \frac{2-3i}{2-3i}$	Multiply by conjugate to eliminate the complex denominator.
$\Rightarrow \frac{(-2+3i)(2-3i)}{(2+3i)(2-3i)}$	
$\Rightarrow \frac{-4+6i+6i-9i^2}{4-9i^2}$	
$\Rightarrow \frac{-4+12i-9i^2}{4-9i^2}$	
$\Rightarrow \frac{-4+12i+9}{4+9}$	
$\Rightarrow \frac{5+12i}{13}$	
$\Rightarrow \frac{5}{13} + \frac{12}{13}i$	Final answer. ■

2.4 $\frac{7+i-4(3-i)}{6-5i^3}$

$\Rightarrow \frac{7+i-4(3-i)}{6+5i}$	$i^3 = -i$
$\Rightarrow \frac{7+i-12+4i}{6+5i}$	
$\Rightarrow \frac{-5+5i}{6+5i}$	
$\Rightarrow \frac{-5+5i}{6+5i} \cdot \frac{6-5i}{6-5i}$	Multiply by conjugate to eliminate the complex denominator.
$\Rightarrow \frac{(-5+5i)(6-5i)}{(6+5i)(6-5i)}$	

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$$\Rightarrow \frac{-30+25i+30i-25i^2}{36-25i^2}$$

$$\Rightarrow \frac{-30+25i+30i+25}{36+25}$$

$$\Rightarrow \frac{-5+55i}{61}$$

$$\Rightarrow -\frac{5}{61} + \frac{55}{61}i$$

Final answer.



$$2.5 \quad \frac{2-2(\overline{i+1})}{2-\sqrt{-4}}$$

$$\Rightarrow \frac{2-2(i-1)}{2-\sqrt{-4}}$$

$$\Rightarrow \frac{2-2i+2}{2-\sqrt{-4}}$$

$$\Rightarrow \frac{4-2i}{2-\sqrt{-4}}$$

$$\Rightarrow \frac{4-2i}{2-2i}$$

$$\Rightarrow \frac{4-2i}{2-2i} \cdot \frac{2+2i}{2+2i}$$

$$\Rightarrow \frac{(4-2i)(2+2i)}{(2-2i)(2+2i)}$$

$$\Rightarrow \frac{8+8i-4i-4i^2}{4-4i^2}$$

$$\Rightarrow \frac{8+4i-4i^2}{1-4i^2}$$

$$\Rightarrow \frac{8+4i+4}{4+4}$$

$$\Rightarrow \frac{12+4i}{8}$$

$$\Rightarrow \frac{3+i}{2}$$

$$\Rightarrow \frac{3}{2} + \frac{1}{2}i$$

Line above a complex number denotes its conjugate.

$$\sqrt{-a} = i\sqrt{a}$$

Multiply by conjugate to eliminate the complex denominator.

Final answer.

